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THE TAPEWORM INFECTION IN WASHINGTON TROUT AND ITS RELATED BIOLOGICAL PROBLEMS

PROFESSOR NATHAN FASTEN

Oregon Agricultural College, Corvallis, Oregon

In the whole realm of nature man is the only creature whose ailments have seriously occupied the attention of experts. Let a disease break out amongst the human family in some corner of the globe and almost immediately the affliction becomes the target for the trained minds of our ablest pathologists. Not so, however, with the maladies of the lower forms. Man's only interest in them has been one of selfish exploitation, and he has done little to encourage investigations along any other lines except those which bring him immediate monetary returns. It is, therefore, not at all surprising that we possess such meager and fragmentary knowledge concerning disease amongst the lower animals.

It is almost superfluous to say that this attitude must change if we are to intelligently conserve the lower creatures as natural resources. In the last few years we have been hearing a great deal about the conservation of natural resources, and yet very few of us realize the full meaning of conservation. To my mind real conservation implies a thoroughgoing knowledge of the objects to be conserved, coupled with an intelligent application of the factors controlling their preservation. We must possess more knowledge concerning the diseases of the lower animals because it is of prime importance in all conservation programs, in that it may be helpful in preventing great losses of animals which are beneficial to man.

In the state of Washington, as well as in the other states of the Pacific coast, fish afford a natural resource of tremendous importance to the welfare of a large proportion of the citizens, and yet comparatively little is known regarding the diseases which affect these aquatic animals. We become alarmed when the fish begin to die in great numbers, and only then are we in any manner concerned with finding out what ails them.

During the summer of 1919 it was my good fortune to be chosen by the Washington State Fish Commission as a special investigator for the purpose of studying the parasites of the fish in some of the fresh-water lakes and streams of the state of Washington. Prior to undertaking these investigations reports had been coming in to the fish commissioner's office that the fish were dying in the mountain lakes and streams of Kittitas county and, therefore, it seemed advisable to spend most of my time in this region studying the nature and extent of the disease. It is with this epidemic in particular that I wish to deal in the present paper. Incidentally, I desire to point out some of the interesting biological problems with which the question is intimately linked up.

On arriving in Kittitas county the writer found that the people, especially the sportsmen, were very much disturbed about the mortality of their lake trout, for they depended upon these fish to yield them spawn for their county hatcheries. They were particularly distressed about the dying of the trout in Cooper lake, and therefore this lake was the first one which I visited.

Cooper lake is situated in the heart of the Cascade mountains about thirty miles outside of Roslyn. Figures 1–3 show various views of the lake. It is a clear body of water, filled with cut-throat trout. The county game commissioners closed the lake some six years ago in order to obtain a plentiful supply of fish for breeding purposes, and as a result of this the trout have multiplied very rapidly within its waters. For the first few years the results obtained were excellent, but within the last two years the fish commenced to die at an alarming rate, so that all spawning operations had to be abandoned.

An examination of the cut-throat trout of this lake showed them to be heavily parasitized with larval tapeworms which attack the abdominal cavity. From all appearances these larvæ somewhat resemble those described by Professor Linton in 1889 for the trout of Yellowstone National Park, and, undoubtedly, belong to the genus *Dibothrium* or *Diphyllobothrium,* but are probably of a

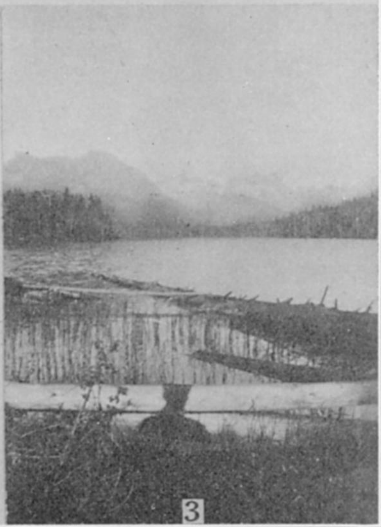
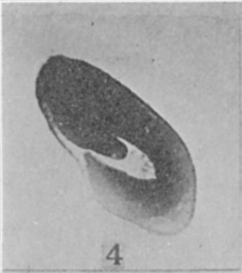
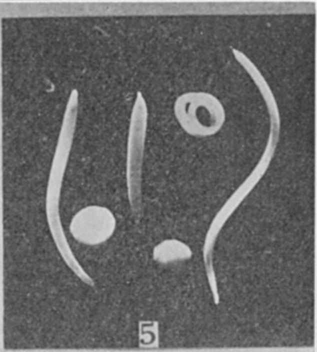


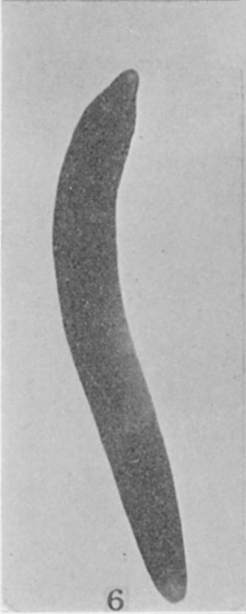
FIG. 1. General view of Cooper lake.

FIG. 2. Region of Cooper lake showing racks, a favorite place for the blue herons.

FIG. 3. Shallow portion of Cooper lake near shore affording an ideal nesting place for fish-destroying birds.







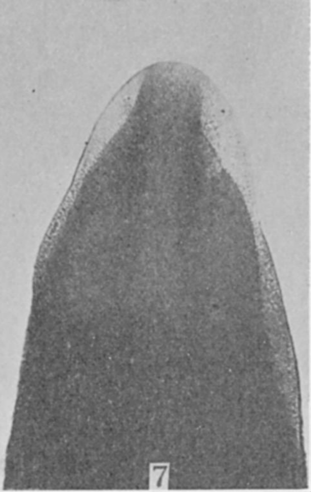


FIG. 4. Tapeworm larva in cyst, × 20.
FIG. 5. Numerous free-boring and encysted tapeworm larvæ, × 3.
FIG. 6. Enlarged photograph of tapeworm larva, × 20
FIG. 7. Head end of tapeworm larva, × 65.

different species from *Dibothrium cordiceps* Leidy, the ones discussed by Linton. According to Professor A. R. Cooper, of the University of Illinois College of Medicine, to whom specimens of the tapeworm larvæ were sent for identification, "the placing of these larvæ specifically is a matter of the working out of the life histories of the species in question."

The larval tapeworms under consideration may be encysted (Figs. 4 and 5) along the walls of the digestive tract, particularly on the stomach, or they may be found burrowing freely amongst the visceral structures, or within the surrounding muscular walls. In appearance they are translucent, whitish or yellowish-white organisms which may vary from a few millimeters to about twenty millimeters in length. They are long, slender and worm-like in character (Figs. 5 and 6). At the anterior end is the head (Fig. 7), which possesses two lateral slits. This head end is constantly changing its shape in the living specimens, becoming slender and spear-like at one time and stouter and knob-like at another time. The body proper of the larva may undergo periodic contractions and extensions. Covering its entire outer surface are stiff, bristle-like structures which, at first glance, seem to resemble cilia, but which do not possess any independent motion. Posteriorly the body tapers off into a blunt rounded margin (Fig. 6).

The damage done to the fish by these larval tapeworms is considerable. In the first place, the fish lose their healthy appearance, becoming much thinner and paler in hue. The parasitic larvæ undoubtedly produce injurious toxins which interfere with the proper functions of the host. Then, again, the burrowing habits of these parasites injure the tissues of the fish, causing them to become mushy. And finally, secondary infections of a serious sort may develop within the injured portions. As a result of all this damage great numbers of the fish die.

The life history of these larval tapeworms is extremely interesting. Those who are familiar with tapeworm infection know that ordinarily two organisms are necessary for the completion of the life history. The adult tapeworm lives in one animal called the *primary host,* whereas the larval tapeworm dwells in another animal called the *secondary host.* The primary host becomes parasitized by eating the infected portions of the secondary host.

In the case of the tapeworm under consideration it is quite obvious that the trout acts as the secondary host.

The primary host, however, is not definitely known. Professor Linton found that in the case of the infection of the trout of Yellowstone Park the white pelican acted as the primary host, and, in the light of this finding, it is quite probable that some similar fish-eating bird is the primary host of the larval tapeworm under discussion.

While at Cooper lake a canvass was made of the common fish-eating birds which visit the lake, and it was found that the blue heron is the most frequent visitor. Since no pelicans are known to come to the lake, I rather strongly suspect that the blue heron acts as the primary host for the larval tapeworms of the trout. If this should prove to be the case then the life history, in all probability, would be as follows: The adult *Diphyllobothrium* tapeworm develops in the intestinal tract of the blue heron, and when the segments become mature they are periodically passed out with the fæces. These mature segments contain large numbers of developing embryos and if they are deposited in a stream or lake the embryos are swallowed by the fish, in which they develop into the larval tapeworms already described. When a blue heron captures one of these infected fish, the larvæ attach themselves to the bird's intestinal wall and shortly develop into adults capable of carrying on the life cycle.

My visit to Cooper lake convinced me that it was pure folly to entirely close down a lake for more than a year or two. In the first place, closing down a lake makes for a rapid increase of fish so that the available food supply soon becomes inadequate for maintaining all of them, with the result that a fierce struggle for existence ensues, in which many of the weaker, but nevertheless desirable, fish are killed off. Even those which survive in the struggle appear to be starved. Secondly, when a lake is closed its shores afford an ideal, undisturbed nesting place for such fish-destroying birds as the blue heron, kingfisher and the like. These birds not only destroy large numbers of fish, but they may be the means of disseminating parasitic infections. And lastly, in the light of the experience in other states, it is a useless waste of money to depend on the fish in a large natural body of water for spawn, because it is very difficult to control the factors which insure success.

Two other mountain lakes were next visited: Lost lake on Roaring creek, near Keechelus, and Fish lake.

Lost lake is stocked with eastern brook and cut-throat trout, with the former predominating in much larger numbers. The lake has been closed for several years and was utilized by the county game commissioners as a place for obtaining eastern brook-trout spawn. From this lake seventy-six brook-trout and two cut-throat trout were examined, and with the exception of two brook-trout all the fish were found to be clean and healthy. The two exceptions mentioned were each parasitized with a single larval tapeworm cyst.

The situation at Lost lake seemed very striking as well as significant, and it suggested the possibility that perhaps the brook-trout are more resistant and immune to the parasitism of the tapeworm larvæ. At any rate, this is worth while testing out much more thoroughly.

One other point which the trip to Lost lake strengthened was in regard to what has already been said concerning the food supply of a closed lake. The fish in this lake, although they were nearly all healthy, were nevertheless very thin. The most prominent parts of them were their heads. In two cases the fish were so hungry that they captured field mice which probably attempted to swim across the lake. These were found partially digested within the stomachs of the fish.

At Fish lake one hundred and nine trout were caught, mainly of the cut-throat species, and a careful examination revealed the fact that they were all healthy and clean. There wasn't a single indication of tapeworm infection. Fish lake was an open body of water and this probably accounts for the healthy state of the fish. When sportsmen can get into a stream they are a source of disturbance to the blue heron and other fish-eating birds, and.

therefore, these birds are prevented from nesting along the shores, thereby protecting the stream from becoming infected with the tapeworm disease.

At the termination of the investigations in Kittitas county, the writer made the following specific recommendations to the county game commissioners:

1. Not to close lakes for more than a short time, say a year or two, and only for the purpose of conserving the fish. When a lake is closed for many years the normal multiplication of fish is such that the food supply within the lake is greatly diminished, resulting in a starvation process. Furthermore, unless adequate watch is maintained, the heron and other fish-destroying birds will live along the shores of these closed lakes and serve as a constant source of infection for the fish.
2. Not to depend on the closed lakes for spawn, but instead to develop a hatchery or a series of hatcheries with numerous outdoor ponds where they can place many of the healthy trout from Lost and Fish lakes, which will give them a constant supply of healthy spawn. They will not only save money by such a project, but their efforts will not be wasted.

After the completion of the above studies the writer examined fish from various places in King county, in which he has found the same larval tapeworm infection. Numerous cut-throat trout of Klause lake near Snoqualmie falls were examined and found to be heavily parasitized. Also, the silver salmon and the so-called red fish or silver trout (which are nothing more than land-locked sockeye salmon) were found to be heavily infected with the same parasites. The striking thing about the parasitism of these last-named fish was that they were more heavily parasitized than any of the fish previously examined in which the tapeworm larvae were found to dwell.

The observations recorded in the present paper make it obvious that a good many of our fish and game cultural practices are utterly wasted because we are ignorant of those factors which ought to insure success. What is urgently needed in the state of Washington as well as in the neighboring states of the Northwest is a series of "Biological Surveys" for the purpose of studying and mapping out the various ecological factors of the regions in which fish or game are to be planted. We ought to know a good deal about such factors as available food supply, oxygen content, temperature variations, predatory and parasitic organisms, etc., of a place before any kind of animals or plants are introduced into it. Knowing *these conditions we can then intelligently fit each* organism into that particular environment where it will thrive best. But without this knowledge we are simply groping in the dark and are powerless to do any real good.